

supposition, in relation to the use of common potash as a substitute for ashes.

I cannot close this communication without referring to the original subject of the revival of prematurely failing peach trees. I have continued to apply ashes in the same manner as at first, in the autumn or spring, or both, to the different kinds of fruit trees; and, I believe, with uniformly favorable results. The peach orchard, which, four years ago, appeared to be in a dying state, and had for several seasons ceased to bear fruit, is now in a vigorous state, and last summer yielded a copious crop. The old apple orchard, which was so wonderfully revived two years since, continues apparently, except in the case of a few trees dying from old age, to hold all that it had gained, though we lost the crop last year through the destruction of the blossoms by a late frost. The pears and quinces of which the blossoming period differed from that of the apple, so that they escaped the frost, were full of fruit; and I was particularly struck with one old quince tree, which, before the use of ashes had borne scanty crops of a small, imperfect, knotty fruit, but, last year, under the influence of ashes, was loaded with smooth and well formed quinces.

I have not yet been able to form any positive conclusion in relation to the protective effect of fresh ashes against the curculio in the plum tree; but I am prosecuting some inquiries in this direction, and hope before long to be able to solve the question either favorably or unfavorably. I must confess, however, that I am by no means sanguine of the former result.

ON THE FAMILIES OF FISHES OF THE CRETACEOUS
FORMATION OF KANSAS.

BY E. D. COPE.

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SAURODONTIDÆ.

Cope. Proc. Amer. Philos. Soc., 1870, p. 529. Hayden's Survey, Wyoming, etc., 1871, p. 414.

A considerable accession of material belonging to several species of this family, furnishes important additions to our knowledge of their structure, and enables me to determine their affinities with more precision than heretofore. The results are of value to the student of comparative anatomy, and also to the palæontologist, as they appear to have been the predominant type of marine fishes, during the cretaceous period, in the North American seas, and to have been abundant in those of Europe.

The characters already assigned to the family are confirmed by the new species discovered, and many additional ones added, as follows:

The cranial structure cannot be fully made out, but the following points may be regarded as ascertained: The *brain case* is not continued between the orbits, and the *basis cranii* is double and with the muscular tube

open. A large lateral cavity is enclosed by the proötic, the pterotic, the epiotic, etc. There are no exoccipital condyles, and that of the basioccipital is a conic cup. The pterotic and postfrontal are well developed. The ethmoid is well developed and slightly narrowed at its anterior extremity. The parasphenoid is narrowed and elongate; the vomer is continuous with it and is slightly expanded and then contracted at the anterior extremity: neither it nor the parasphenoid support teeth in any of the known genera.

The premaxillary bones are short, and form but a small portion of the upper jaw. The maxillary is elongate and simple. The hyomandibular is rather narrow and does not present an elongate peduncle for the operculum. The symplectic is well developed, entering far into the inferior quadrate. The latter is a broad bone, largely in contact with the meta-ptyergoid, which is itself a thin plate, not probably attaining the pterotic. The superior branchi-hyals are short rods.

The relations of the supraoccipital, parietals, frontals, etc., cannot yet be satisfactorily made out, owing to the obscurity of the sutures. Nevertheless the following points may be regarded as probably reliable. The frontals have a rather broad union with the ethmoid, and are separated by suture throughout their length. They do not extend much posterior to the orbits and are succeeded by a rather narrow pair of bones which extend to above the *foramen magnum*. These are not united by suture, but present thickened smooth edges to each other, and appear therefore to have been separated by a fontanelle. Each is separated by serrate suture, from a broad lateral bone which is perhaps the pterotic, and certainly includes that element, as it supports the hyomandibular. It is not easy to determine what relation the median bones bear to the supraoccipital, but the structure looks a good deal like that characterizing the *Siluridae*, or, considering the large pterotics, like the *Mormyridae* plus the fontanelle. The shorter form of the pterotic in the *Characinidae* and the *Catostomidae* causes considerable difference in their appearance. There is no indication of fontanelle between the frontals in *Portheus*.

Portions of the scapulæ of *Portheus molossus* and other species, are preserved. They have very stout articular surfaces, and although not complete, have enclosed, more or less, a very large fontanelle. The superior surface is the larger, and is followed below by two others, the upper subvertical and small, the lower larger and transverse. These are surfaces supporting two basilar elements of the pectoral fin. There were perhaps three basilars, but the base of the coracoid displays no surface for articulation of a third. The suture with the coracoid crosses immediately below the lower condyloid surfaces, and passes just below the scapular fontanelle, leaving in the specimens a fractured surface which probably supported a præcoracoid. There are two fractured bases of the coracoid, which probably unite below, enclosing a foramen. On the scapulo-coracoid suture just within the space between the two inferior condyles is a smooth hemispherical pit of considerable size. Just in front of it is another of crescentic form.

A partially complete circle of bones convex on one side, concave on the other, was found with the remains of two species of *Portheus* and one of *Ichthyodectes*. They look like a *sclerotic ossification*, and as though moulded on a globe. They are not segmented as in Reptilian sclerotic ossifications, nor do they seem to have been completed circles.

The *femoral bones*, or those supporting the ventral fins are preserved in *Ichthyodectes anaides* and a *Portheus*. They are closely united posteriorly, the inner margins gradually approximating to the union, which is accomplished by the application of the subcylindric posterior part of the bones. In *Portheus* they are united by a coarse suture. There are no posterior processes, but the anterior are long and slender. Each is divided, the inner portion being rod-like; the exterior plate-like. The outer is probably the shorter; exteriorly it rises into an obtuse ridge on the lower side, and the plate then expands backwards as well as outwards nearly enclosing a large sinus with the base of support of the fin. The fin-supporting surface is sub-round, with two exterior and one interior articular surfaces, and a projection in the middle, which has one or two articular faces of smaller size. The base of the anterior projections is rather broader in *Ichthyodectes* than in *Portheus*.

Three kinds of *spine-like rays* or supports of the fins have been found in connection with remains of species of this family, and the proper reference to their positions and species is as yet in some degree uncertain. First. The elegantly segmented compound rays originally referred to *Ptychodus* by Agassiz, and described by me under the species *Saurocephalus thauomas*, appear to be referable to the genus *Portheus*, and to be supports of the caudal fin.* Secondly. Spines composed of unsegmented rays closely united edge to edge, and arranged like the fulera at the base of the external rays of the caudal fin of recent fishes. That is, the first very short; those succeeding, increasing very regularly in length to the last, which forms the apex of the spine. The obliquely truncated extremities of these rods form a continuous sharp edge, which is coated with enamel, and may be straight, or interrupted with low knobs. The former kind belongs probably to *Portheus* and the latter to *Ichthyodectes*. It is nearly related in character to the spines of *Edestes*, the enamel coated knobs of *Ichthyodectes* rising into veritable teeth in the carboniferous genus. These spines are unsymmetrical, and belong either to the pectoral or ventral fins. To which they should be referred, it is not now easy to decide. The living allies of the *Saurodontidæ* do not possess ventral spines, nor do they exist in Physostomous fishes. In the *Siluroids*, the pectoral fins are supported by strong spines, which remotely resemble the present ones in their compound character.

Third. There are numerous flat, more or less curved, spines or rays, of small diameter compared with the length. One surface is covered with a thin, generally striate-grooved layer of enamel, and one edge is trenchant. One side of this edge is more or less obtusely rugose, or thickened.

* See Hayden's Report, *l.c.*, p. 423, where this view is held.

These rays thin out to the extremity, which in some cases at least is not contracted. These rays are composed of appressed halves, are unsymmetrical with basal hook, and belong no doubt to paired fins. If those already described are pectoral, these are ventral, and *vice versa*. A series of them found together had much the form of either of these fins, while their number would identify them with the ventral. In the rays found together, the first only had a trenchant outer margin, while several had a rabbet along one side of the posterior margin. I have already described such a spine as pertaining to the pectoral fin of *Ichthyodectes prognathus*.

The *vertebræ* in all the species certainly assignable to this group, are where known, deeply two-grooved on each side, besides the pits for the insertion of neurapophyses and pleurapophyses, except in the cervical region where the lateral grooves are wanting. There are no diapophyses. The caudal *vertebræ* are rather numerous but not so much so as in *Amia*, nor are they so much recurved as in that genus.

Until the structure of the posterior cranial roof and of the scapular arch are fully made out, it is premature to state precisely the affinities of this family. So far as known they are *Isospondyli* with some characters of the *Salmonidæ*, and some of other significance. The large foramen behind the proötic bone is more *Clupeoid* in character. The femoral bones are more like those of the *Plectospondyli*, dividing in a measure characters of the *Cyprinidæ* with those of the *Mormyridæ*. The *vertebræ* are *Clupeoid*, while the mode of implantation of teeth is peculiar.

SYNOPSIS OF GENERA.

- I. Jaws without foramina on the inner face of the alveolar margin.
Teeth of unequal lengths in the maxillary and dentary bones.. *Portheus*.
Teeth of unequal lengths, cylindric..... *Ichthyodectes*.
II. A series of foramina on inner side of alveolar wall.
Teeth with sub-cylindric crowns..... *Saurodon*.
Teeth with short compressed crowns..... *Saurocephalus*.

There are some other forms to be referred to this family, whose characters are not yet fully determined. Thus *Hypsodon* Agass., from the European chalk is related to the two genera first named above, but as left by its author in the *Poissons Fossiles*, includes apparently two generic forms. The first figured and described, has the mandibular teeth of equal length. In the second they are unequal, as in *Portheus*, to which genus this specimen ought, perhaps, to be referred. Both are Physostomous fishes, and not related to the *Sphyrænidæ*, where authors have generally placed them. Retaining the name *Hypsodon* for the genus with equal mandibular teeth, its relations to *Ichthyodectes* remain to be determined by further study of the *H. levesiensis*.

A species of *Ichthyodectes*, from the chalk of Sussex, England, is figured but not described, by Dixon, in the *Geology of Sussex*.

A number of forms, erroneously referred by Agassiz and Dixon, to the genus *Saurocephalus*, have been referred by Leidy to a genus he calls

Protosphyraena,* with two species, *P. ferox* and *P. striata*. The latter much resembles a *Saurocephalus*, having equal teeth; while the former probably includes several species, and possibly genera. The teeth first referred to it resemble those of *P. striata*, while others resemble those of *Portheus*. An examination of the figures of the mandibles of the last in Dixon's work, show that the large and small teeth occupy different areas, separated by grooves in a manner quite distinct from anything seen in *Portheus*; but, should it prove identical, it can scarcely be regarded as typical of *Protosphyraena*, which name, moreover, has never been accompanied by the necessary description.

Dr. Leidy applied the name of *Xiphactinus* to a genus indicated by a spine, in some degree like those regarded above as ventrals of *Saurodontidae*. It is quite distinct from those assigned to *Portheus* and *Ichthyodectes*, and may belong to *Saurocephalus*, as already suggested, or to another genus.

PORTHEUS. Cope.

(*Proceed. Amer. Philos. Soc.*, 1871, p. 173.)

Teeth subcylindric, without serrate cutting edges, occupying the premaxillary, maxillary and dentary bones. Sizes irregular, the premaxillary, medium maxillary and anterior dentary teeth much enlarged. No foramina on inner face of jaws. Teeth on the premaxillary reduced in number. Opercular and preopercular bones very thin. Cranial bones not sculptured.

The fishes of this genus were rapacious, and, so far as known, of large size. They constitute the most formidable type of Physostomous fishes known. Three species are known to the writer, one from teeth only, from the Miocene of North Carolina, but not certainly known to be an intrusive cretaceous fossil; and two from Kansas. The latter are represented by more or less numerous fragments of eleven individuals, three of which possess large portions of the cranium, one almost entirely complete. Two of the remainder embrace jaws, and one a large part of the vertebral column, with segmented rays. In one, these rays were found with the cutting compound ray above described; while the simple flat ventral rays occur with several specimens. In none have any traces of symmetrical spinous rays been found, nor strong interneurals capable of supporting such. In none of the more perfect specimens with crania have the segmented always been found, but the fossil of *P. thaumas*, where they occur, is represented by a vertebral column and its appendages, which do not differ appreciably from those of *P. molossus*.

In the *cranium* of this genus, there is a well-marked supraorbital rim. Each opisthotic forms a prominent angle, directed posteriorly on each side of the exoccipital. The parasphenoid is a stout and narrow bone, deeply emarginate behind, for the passage of the muscular canal. It has a transverse expansion in front of the base of the proötic, which rests on a backward continuation of the same. This expansion is pierced behind

* *Trans. Amer. Philos. Soc.*, 1856.

by two round foramina. The shaft is abruptly contracted in front of the expansion, and is trigonal in section. The prefrontal extends downwards and forwards, and carries inferior and anterior articular faces; the latter vertically transverse. The postero-inferior portion of the ethmoid bears on its posterior extremity a concave articular face, which opposes that of the prefrontal. The floor of the brain-case in front is supported by a vertical style, which is bifurcate above, and rests on the parasphenoid.

Of the *teeth*, in general, it may be added that their pulp cavity is rather large at the base, but rapidly diminishes in the crown. The mode of succession is by direct displacement from below. The young crown rises into the pulp cavity, and destroys the vitality of the crown, while the root is absorbed. Numerous empty alveoli are to be found in all the jaws of this genus, in which examination will often detect the apex of the crown of the young tooth.

The *vertebræ* in this genus are rather short, but not so much so as in sharks. In *P. thauwas*, nearly eighty dorsals and caudals were preserved; those without lateral grooves, or cervicals, are not numerous. There are, perhaps, not more than four vertebræ supporting the caudal fin, though this is difficult to determine, owing to the concealment of the terminal centra by bases of radii. There are seven hæmapophyses in the support, all flat except the first, which is like those anterior to it. The second is articulated freely to its centrum, and is wider than the others. Its condyle is characteristic, being double, and with a foramen between it and the produced extremity of posterior margin of the bone. It is slightly separated distally from the third, but the remainder are in close contact. The radii of the superior lobe of the caudal fin extend at least as far down as near the end of the third hæmal spine from below. The structure of these parts in the *P. molossus*, are as in *P. thauwas*, so far as preserved.

As some of the *spines* are not referable to their precise species in this genus, they may be described here. A large compound spine found in the blue limestone shale in Fossil Spring Cañon, is composed at the base of about twenty-six narrow double rods. A few appear between the others beyond the base making thirty-one altogether. They are very oblique to the general base, but curve so as to become nearly straight, and enlarge distally. They terminate in a thickened portion which bears an acute edge, which truncates them obliquely, forming the cutting edge of the spine. This portion is enamelled; the edge is slightly convex at the base, and slightly concave at a point probably beyond the middle.

	M.
Length of fragment (12 inches).....	0.30
Width at base.....	.12
Thickness at base.....	.012
Thickness at broken end an inch from edge.....	.007

This is a formidable weapon and could be readily used to split wood in its fossilized condition.

The third form of spine is represented in most of the species, but one series of rays with spine may not be referable to any of them. The latter is flat and curved, the convex edge trenchant beyond the middle. The posterior edge is obtuse but narrow, and exhibits a slight groove on one side medially; proximally there is a shallow rabbet whose floor is transversely rugose. Several layers of the tissue of the spine beyond the basal portion are delicately longitudinally striate. The distal half is broken away; length of fragment, one foot; width, 1.5 inches; thickness at middle, 5 lines.

The species of this genus may be distinguished as follows:

a, Teeth without acute edges.

Large maxillaries five; second premaxillary larger than the first; third mandibular large, behind a cross-groove; last large mandibular followed by 16,—8 small teeth.....*P. molossus*.

Large maxillaries, three; first premaxillary larger than second; third mandibular small, no cross-groove in front of it; twenty small teeth behind last large mandibular.....*P. thaumas*.

aa, Large teeth with cutting angle in front.

Teeth large, not compressed.....*P. angulatus*.

PORTHEUS MOLOSSUS. Cope.

(Proc. Amer. Philos. Soc., 1871, p. 173.)

Represented by four individuals, one from Fox Cañon, near Fort Wallace, with complete cranium, and many vertebræ and radii; a second from another part of the same ravine with large part of cranium, and a third and fourth from lower Butte Creek bluffs, both with fragments of cranium and other portions. In the first specimen the jaws are perfect and dentition complete.

The *premaxillary* is vertically oval, convex externally, nearly flat within, and more than half underlaid by an anterior lamina of the maxillary. The anterior or median margin is regularly convex and exhibits no surface or suture for union with the bone of the opposite side. Its posterior margin extends obliquely backwards to beneath the superior articular condyle of the maxillary and has a ragged margin, though the suture is squamosal. Its superior margin is deeply inflected in front of the condyle and then convex and thickened. The anterior margin is thick and rugose with tubercular exostoses. There are but two teeth, which are very large, and directed obliquely forward; the first is two-thirds the diameter of the second.

The *maxillary* is a large laminiform bone, with the upper margin considerably thickened proximally but much thinned distally. It is abruptly contracted at the distal two-thirds its length, apparently for the attachment of a supernumerary bone. The extremity is curved sabre-shape upwards, and has an acute toothless edge. The teeth are, four small, five large, and eighteen small. These teeth, except the largest, have cylindric bases; the crowns (and bases of the latter) are slightly compressed or

oval; they are straight and regular, and lean backwards. The middle one of the five is largest, being six times as long as the small ones, but little more than half as long as the large premaxillary or mandibular. The surface of the maxillary is rugose with small tubercles on its lower half, and has shallow grooves for nutritious vessels running downwards and forwards.

The *mandibular rami* are short and deep, and have but little mutual attachment at the symphysis. They are not incurved at that point, and were bound by ligament only. There is no coronoid bone and the articular is distinct. It is short, of a rather irregular wedge shape, and supports half the cotylus, above which it sends a short acuminate process. The angular has a prominent angle, like half an ellipse somewhat contracted at the base; below it has a rough prominent muscular insertion. The bone extends in a long sword-shaped process, on the inside of the ramus to beyond its middle; externally, it is soon covered by the thin truncate edge of the dentary. This element is very large. From the angular it rises steeply to a coronoid process, which has a slight outwardly twisted eminence, and then follows a gently concave line to the symphysis. The teeth are as follows: two large, a transverse groove; three large, four very small, nine medium, and two very small; total twenty. These teeth have straight cylindric-conic crowns, with enamel without striæ or facets. The larger are a little compressed.

Measurements of Jaws and Teeth.

	M.
Length premaxillary bone.....	.007
Depth " " .....	.093
Thickness on alveolar margin.....	.016
Length crown of second tooth.....	.046
Diameter do. at base.....	.014
Length maxillary bone from premaxillary.....	.270
Depth " at condyle.....	.08
" " at middle.....	.046
Length crown third large tooth.....	.028
Diameter do. at base.....	.011
Length crown second small tooth from large.....	.006
Diameter do. at base.....	.004
Length ramus mandibuli.....	.350
" of angle.....	.04
" of angular bone anteriorly.....	.08
Depth at coronoid process.....	.112
" at fourth tooth.....	.08
Length crown first tooth.....	.038
Diameter do. at base.....	.011
Length crown fourth tooth.....	.055
Diameter do. at base.....	.016

The *opercular bones* are thin; the operculum broad, the preoperculum

rather narrow. The latter is without armature, and has some depressed grooves radiating towards the circumference. Length of bone vertically, M. .245; radius from inner curve, .09.

The *vertebrae* display deep lateral grooves; articular faces smooth. Length centrum, M. .028; diameter, .043. The fan-shaped hæmal spines, or second of the caudal fin is like that of *P. thaumas*, but smaller. The last caudals contract in size very rapidly; the cup of the penultimate or last is transverse diamond shaped.

The fragments of the sabre-shaped *spine* display several layers of parallel striate dense bone, and the edge is tubercularly dentate, and one side is much more rugose than the other. At the base, one side is flat; the other convex, and there is a transversely rugose band near one edge.

The *scales* are thin and cycloid, and though large are not remarkably so for the size of the fish.

Measurements of Cranium.

	M.
Length from angle of opisthotic to anterior extremity of ethmoid.....	0.30
Length from same to front of proötic.....	.11
“ “ postfrontal to prefrontal across orbit.....	.11
“ “ occipital condyle to transverse process of parasphenoid.....	.117
Length from do. to bottom parasphenoid emargination	.055
“ parietal bone on outer suture.....	.07
Width do. at middle.....	.014
“ do. to edge pterotic.....	.07
“ frontal at middle orbit.....	.04
“ parasphenoid do. ....	.03
Length inferior quadrate.....	.10
“ condyle of do.	0.03
“ symplectic.....	.064

The gape of the mouth of the *Portheus molossus* extended the whole length of the cranium proper, and far beyond the orbits, since the maxillary reaches to opposite the occipital condyle. The orbits were large. The lower jaw was deep, and gave the countenance that bull dog expression from which it derives its name. The body was short or moderately elongate. As materials for a restoration of this fish exist, I will give one at a future time.

PORTHEUS THAUMAS. Cope.

(*Saurocephalus thaumas*, Cope. Proceed. Amer. Philos. Soc., 1870, November. Hayden's Survey, Wyoming, etc., 1871, p. 418.)

This large species rests on a specimen without cranium, originally procured by Professor B. F. Mudge. The parts preserved are not distinguishable from the corresponding ones in two individuals obtained by myself in Western Kansas, which include the greater portions of the jaws

and suspensorial apparatus. These indicate larger animals than those of *P. molossus*, and probably indicate the most powerful of the Physostomous fishes, equaling in this respect many of the saurians which were their contemporaries.

The distinguishing features of the species have been already pointed out.

The *premaxillary* is an obliquely oval bone or subpentagonal; the suture with the maxillary is not toothed, and the anterior or free edge is smooth, not tubercular as in two specimens of *P. molossus*. There are but two teeth, of which the anterior is immense, and the second little more than half its diameter. The *maxillary* is stout, and supports in front four very small teeth, then three very large, of which the median is largest. The teeth recommence very small and closely placed in the same line; but as the extremity of the maxillary is lost, the number cannot be stated.

The *dentary* is similar in form to that of *P. molossus*, but has rather more numerous teeth. Counting from the front there are two large, one rather small, two large, and eighteen small and medium following, the smallest from third to ninth, inclusive. None of the crowns are preserved, but the alveoli are round or nearly so. The large tooth of the premaxillary if proportioned as in *P. molossus* must have projected M. .0755, or three inches above the alveolus; the fourth mandibular was but little smaller.

Measurements of Jaws.

	M.
Length premaxillary.....	.075
Depth ".....	.09
Depth maxillary at condyle.....	.08
Thickness " just behind condyle.....	.025
Length dentary.....	.25
Depth " at symphysis.....	.08

The various portions of *cranial bones* preserved are much like those of *P. molossus*, but stouter. The hyomandibular is nearly perfect: it is thin, but has a convex rib extending to its acuminate extremity at the posterior-inferior angle of the metapterygoid and the superior extremity of the symplectic. The preoperculum is attached by a thickened grooved margin, and is not overlapped by the hyomandibular. It extends in a curved form round towards the angle of the inferior quadrate. Three elongate bones, closely appressed, I suspect to be part of this bone, with interoperculum and superior ceratohyal. The last is rather narrow, and with smooth distal articular surfaces, without suture. The superior branchiyls are a little like phalanges of Mosasaurus in form, being sub-similar and expanded at the ends, and quite alternated. The parasphenoid is similar to that of *P. molossus*. The position of the hyomandibular is vertical to the axis of the basioccipital; the superior part directed forwards.

	M.
Length basioccipital to end muscular foramen.....	0.077
“ hyomandibular .....	.26
“ inferior quadrate (oblique) .....	.113
“ condyle of quadrate.....	.036
“ preoperculum preserved.....	.035

A portion of one of the flat unsegmented spines preserved exhibits an irregular rabbet on each edge of one side; width, .042 M. The sclerotic bones are as already described.

A second specimen is still stouter in proportions, as the following measurements show :

	M.
Diameter maxillary condyle,.....	.034
Diameter maxilla above, behind condyle.....	.033
Length angle jaw (exteriorly).....	.056
Diameter parasphenoid at middle of preotic.....	.03
Diameter dorsal vertebra (crushed).....	.067

The diameter of the vertebra must be a little corrected by reduction.

The largest fish vertebræ obtained may be here mentioned. They are peculiar in having numerous concentric grooves on the articular faces, as in *Ischyrrhiza*. They are otherwise as in this genus. Length, M. 04; diameter, .062.

A peculiarity of *dentition* is observable in the two specimens first described, and in less degree in *P. molossus*. A considerable number of alveolæ support no functional teeth (though included in the enumeration), but are occupied at some point by successional teeth. In some cases the mouth of the alveolus appears to be narrowed by ossification, even where the tip of the young tooth is in sight; in one case so far developed as to close up to the projecting apex. In other cases the orifice is entirely stopped by the ossification, which presents the appearance of a scar, with radiating lines of pores.

The type specimen was discovered in a denuded area among the lower bluffs of Butte Creek. The flat cranial and jaw-bone occupied the summit of a cone of twenty or more feet in height, a relic of the ancient blue limestone spared from the surrounding denudation. The flat bones had shed off the water, which, running off on all sides, had formed the cone. The second specimen came from the Fossil Spring Cañon, near the remains of *Liodon curtirostris*.

PORTHEUS ANGULATUS. Cope.

The crown of the tooth which indicates this species is slender, compressed, and curved backwards, and a little inwards. The circumference is divided by two edges, the anterior acute, the posterior obtuse; the convex faces separated by these are not equal, that towards which the crown is curved laterally, *i. e.*, the inner, being somewhat more extensive, and considerably more convex.

Enamel smooth, without sculpture; anterior cutting edge without crenations, more curved backwards than the posterior, which has but little curvature. Inward curvature slight.

	Lines.
Diameter (anteroposterior) at middle crown	5
“ transverse at middle crown	4
“ “ near tip	3
“ anteroposterior, near tip	2

Discovered by Prof. C. Kerr, State Geologist of North Carolina, in the Miocene marl, Duplin Co., North Carolina, with *Polygonodon rectus*, and *Ischyrrhiza antiqua*, Leidy.

ICHTHYODECTES. Cope.

(*Proceed. Amer. Philos. Soc.*, 1870, Nov. *Hayden's Geol. Survey, Wyoming*, etc., 1871, p. 421.)

Teeth equal subcylindric, in a single row, sunk in deep alveoli. Pre-maxillaries short. No foramina at the bases of the teeth on the inner alveolar walls. Vertebrae deeply grooved laterally.

The species of this genus are, so far as known, smaller than those of the last; and as their remains are more perishable than those, they form a less striking object among the fossils of Kansas. They are nevertheless, very abundant, especially in species, five of which are now described. In originally describing this genus, the vertebrae were regarded as not grooved, in consequence of such vertebrae having been discovered along with the bones and teeth of *I. ctenodon*. Further examination has satisfied me that this union is erroneous, and that the bones, if found together, were accidentally so.

Spines similar to those of the *Porthei*, but presenting certain differences, may be referred to this genus. The compound segmented spines cannot be ascribed to it, but the compound fulcrum-like spines are similar, though composed of fewer and stouter rods. Each of these, as it terminates at the cutting edge, give rise to a projection, giving it an obtusely and remotely serrate character. It is rugose with enamel deposit, and constitutes as effective a weapon of defense as that of *Portheus*. One, which is nearly perfect, contains fifteen pairs of rods, which expand at the base, as do the rays of a pectoral fin. Total length, M. .235; width, at base, .04; thickness beyond base, .006.

The femoral bones have already been described. The maxillary is not contracted at the end for a supernumary bone, as in *Portheus*.

The form of the inferior quadrate is like that of *Portheus*; in *I. anaides*, the groove for the preoperculum extends low down, and the symplectic has a wider exposure on the outer face than in *Portheus*.

In a series of vertebrae similar to those of this genus, those included in the basis of the caudal fin are not more than three in number.

The species are distinguished as follows :

- Premaxillary teeth five ; second most prominent ; maxillary not concave ; dentary with 30 teeth and bi-convex alveolar border, with obtuse extremity..... *I. anaides.*
- Premaxillaries (?) ; maxillary straight, large, with 40 teeth ; dentary straight, not produced at end ; teeth 26.... *I. ctenodon.*
- Premaxillaries five ; first most prominent ; maxillary, narrow concave ; teeth small ; dentary with a hook at apex ; teeth 25..... *I. hamatus.*
- Premaxillaries seven ; first most prominent, compressed ; smaller..... *I. prognathus.*
- Premaxillaries twelve ; second most prominent, the bone much narrowed above ; smaller..... *I. multidentatus.*

The English species of this genus is figured by Dixon in the Geology of Sussex, pl. xxxii.*, figs. 9 and 9*. I can find no letter-press or name relating to it, and cannot determine its specific characters from the fragmentary character of the piece of mandible figure.

ICHTHYODECTES ANAIDES. Cope. sp. nov.

Indicated by two individuals, one with both dentary bones and teeth, with vertebræ, the other with many portions of cranium, fin rays, vertebræ, and other elements more or less separated. The latter were all taken from the upper face of a spur of a limestone bluff, elevated about five feet from the ground level, where they were denuded and exposed as on a table, prepared for the use of the geologist.

It is the largest species of the genus, and the anterior premaxillary teeth are larger than the posterior. The *premaxillaries* are oblique ovoids, very convex on the external face, thinning laterally and above. The superior margin presents a thickening, bearing an articular surface, while behind it is an open gutter-like inflexion. The large teeth are quite cylindrical. Both these bones are preserved. But part of the right *maxillary* remains. It is thickened above in front of the condyle and is regularly convex at that point. The teeth are small, there being 10.5 in an inch. The margin is not concave.

The mandibular rami are preserved almost entire. They are short and deep, and have a short angular process, which is relatively shorter than in *Portheus*. The margin rises steeply to the dentary, which presents a narrowed rectangle behind. The alveolar margin has two convexities with a depression between ; the symphyseal angle is not prominent. The lower posterior angle of the dentary is quite prominent for muscular insertion. The crowns of the teeth are cylindrical, slightly curved inwards. The dentary bones of the second specimen coincide with these in all respects.

Thirty-three *vertebræ* are preserved, all deeply two-grooved on the sides. The ribs are articulated by a sigmoid surface to a broad short element of a sigmoid form which is inserted in the lateral groove of the inferior face, or articulated by gomphosis.

The spines already noticed are quite flat, without serrate edge, but with some rugosities near the edge on one side only. There are no grooves on the upper side, but the dense bone is delicately striate; distally grooved.

Measurements.

	M.
Length premaxillary.....	0.033
Depth ".....	0.045
Depth maxillary at condyle.....	.037
Thickness " just behind condyle.....	.012
Length mandibular ramus.....	.172
" angular process.....	.014
Depth at coronoid process.....	.058
" " symphysis.....	.041
Length of eight vertebræ.....	.212
Width of articular face.....	.030
" " a rib.....	.004
" flat spine at middle.....	.025
Length " (fragment).....	.155
" condyle inferior quadrate.....	.02

The scales associated with this species were thin and cycloid, and difficult to preserve.

From near the Smoky Hill River, Kansas.

ICHTHYODECTES CTENODON. Cope.

(Proc. Amer. Philos. Soc., 1870, Nov. Hayden's Geol. Surv., Wyoming, etc., 1871, p. 421 part.)

Found by Professor Mudge on the North Fork of the Smoky Hill River; common in many other localities.

ICHTHYODECTES HAMATUS. Cope. sp. nov.

Represented by a considerable number of remains of an individual from the blue cretaceous shale near Russell Spring, on the Smoky Hill River.

The characters which distinguish this species from *I. anaides*, are numerous, but they are less marked when compared with those of *I. ctenodon*, partly because the premaxillary bones of the latter have not been preserved. In the first place, the dentary bones of the two are of equal length and support the same number of teeth; it is concave at the proximal part of the tooth line, but is straight in the corresponding part of *I. ctenodon*. The end of the dentary is furnished with a strong obtuse process or hook, directed upwards and forwards, not seen in *I. ctenodon*. The maxillary behind the premaxillary is, in this species, thickened, and with two articular surfaces, the proximal looking outwards, the distal inwards and separated by an oblique ridge from the condyle. In *I. ctenodon*

there is but one smooth surface gradually narrowing with the thinning of the bone from the condyle.

The *premaxillary* is less extended antero-superiorly than in the species already described, but supports, as in it, an articular face. There is no groove behind it, as in *I. anaides* and *Portheus*. It displays a surface for osseous articulation to near its extremity on the inner side, while below it, and on the external face, near the basis of the first and second teeth, the surface is rugose; maxillary teeth 43. The dentary supports 25. The anterior hook is obtuse, and rises abruptly to above the apices of the crowns of the teeth. It is knobbed above, and supports a tooth not larger than the others.

All the cranial bones preserved are not sculptured.

Portions of the thin *flat spines* display the delicately-grooved striation already observed, while the trenchant edge is bordered on one side by raised *longitudinal striæ*. The other side is minutely pitted.

The vertebræ are anterior, and without lateral grooves. Three of them are M. .06 in length; an undistorted one is a little wider than deep, and the cup is .026 across.

Measurements.

	M.
Length ramus mandibuli.....	0.174
Depth at symphysis.....	.055
" premaxillary (oblique).....	.043
Length " " .....	.026
Depth maxillary at condyle.....	.027
" " behind " .....	.033
" " near middle.....	.027
Width flat spine.....	.031

This species, and the two preceding, were not very unlike in size; the two following are smaller.

ICHTHYODECTES PROGNATHUS. Cope.

(Proceed. Amer. Philos. Society, November, 1870. (*Saurocephalus*.) Hayden's Geol. Survey, Wyoming, etc., 1871, p. 417.)

In this species the premaxillary is more rhomboid in outline than in the others, and is less convex externally. Of its more numerous teeth, the first is not larger than the last, differing thus from all others of the genus, and it is in line with the nearly straight anterior margin of the bone. It is more compressed than in the other species, whence I originally placed it in *Saurocephalus*. To this genus it does not belong, as the absence of marginal alveolar foramina shows. The surface of the bone is peculiar; in a minute sculpture of impressed lines, or lines of punctæ. There is a very small articular surface on the superior extremity.

From the North Fork of the Smoky River.

ICHTHYODECTES MULTIDENTATUS. Cope. sp. nov.

Here we have again the convex *premaxillary* of the larger species, with more numerous (12) teeth than in any other of the genus. These increase in size to the first three, the last being small. The second and third are about equally prominent, and more so than the first. The bone is much contracted above, there being an excavation on the anterior border and contraction from behind. The superior edge is thin, and *without trace of articular surface*. Alveolar edge somewhat rugose. The *maxillary* is both narrow and thin, but is only partially preserved. It bears five teeth on M. .01. One of these, with complete crown, displays a longitudinal angle on the antero-interior face.

No other remains were preserved.

	M.
Length of premaxillary.....	0.039
Depth " (oblique).....	.023
Length of tooth line.....	.025

From near Fossil Spring, W. Kansas.

SAUROCEPHALUS. Harlan.

Leidy has pointed out the mode of implantation of the teeth in the typical species of this genus. The mode of succession of the teeth has not yet been indicated, but is well displayed in a specimen of the jaw of *S. arapahovius*, Cope. It is known, from Harlan's description, that a large foramen issues on the inner wall of the jaw, opposite each root. The fractured ends of the specimen exhibit the course of the canal which issues at this foramen. It turns abruptly downwards between the inner wall of the jaw and the fang of the functional tooth, and not far from the foramen. Its course is interrupted by the crown of the successional tooth. This is situated obliquely as regards the long axis of the jaw.

It is thus plain that, the successional appearance of teeth is different in this genus from what I have described in the two genera preceding. In them the foramen is wanting, and the young crown rises within the pulp cavity of the functional teeth, as in the *Crocodylia*. In this genus, on the other hand, it is developed outside of the pulp cavity and fang of the old tooth, and takes its place as in many *Lacertilia* and in the *Pythonomorpha*, by exciting the absorption of the latter. The obconic form of these fangs in *Saurocephalus* is appropriate to such a succession, and their great length seems to preclude the nutrition of the young tooth from their bases. The use of the foramina on the inner face of the jaw is thus made apparent, viz., the nutrition of the successional teeth from without. I cannot trace the canal below the crown of the young tooth to the base of the pulp cavity of the old tooth; and there are canals in the jaw, below the latter, one of which probably carried the dental artery.

Species of this genus are less abundant in the part of Kansas examined by me than those of the preceding genera. Two only have been observed up to the present time, as follows:

SAUROCEPHALUS PHLEBOTOMUS. Cope.

(Proceed. Am. Philos. Society, Nov., 1870. Hayden's Geology, Wyoming, etc., 1871, p. 416.)

Solomon River Region. Prof. Mudge.

SAUROCEPHALUS ARAPAHOVIUS. Cope.

Established on a portion of a maxillary bone, with a part of a suture, perhaps for attachment to a supernumerary maxillary. The size of the species is nearly that of *S. lanciformis*, and the crowns of the teeth are rather short, as in that species, and less elongate than in *S. phlebotomus*. The teeth are very closely set, and the alveoli are separated by very narrow septa. The crowns are expanded, so that the edges overlap in some cases. The form of these is much compressed, width about equal to height, the edges convex and acute. The enamel is smooth and without facets. The roots are without the facets, shown by Leidy to exist in *S. lanciformis*, and appear to be longer than in that species, exceeding the length of the crown nearly four times. None are, however, perfectly exposed for complete measurement. As usual, there is a large foramen opposite each fang, below the inner alveolar margin, and between the latter and the series of foramina the surface is slightly convex and minutely rugose.

	M.
Depth of bone .....	.035
Thickness at rugose band .....	.0055
Total length of a tooth (?) .....	.02
Length of a crown .....	.0043
Width " .....	.0036
Number, etc., in an inch	8.

The size of this fish was probably about equal to that of *Ichthyodectes anaides* above described. Found loose on a cliff of blue shaly limestone, fifteen miles south of Fort Wallace, Kansas.

PACHYRHIZODONTIDÆ.

This family of Physostomous fishes differs from the last in the nature of its dentition. Instead of elongate conic fangs sunk in deep alveoli, it has shorter and stouter fangs occupying alveoli, of which the inner side and part of the anterior posterior walls are incomplete. The teeth are, in fact, more or less pleurodont, but the extremity of the root is received into the conic fundus of the alveolus.

The premaxillary bones are well developed, but the maxillaries are more so, and enter largely into the composition of the border of the mouth. There is a well-developed angle of the mandible, but no coronoid bone is preserved in the specimens. The coronoid region is, however, broken in all our specimens. The other characters of the family are not determinable from our imperfect materials.

PACHYRHIZODUS. Agassiz.

Dixon's Geology of Sussex, 1850, p. 374.

This genus was established by Prof. Agassiz, on a jaw fragment from Sussex, England, with a very brief description. The Kansas remains resemble this fragment in their corresponding parts, and I refer them to the same genus for the present.

The genus as seen in our fossils, is defined as follows :

Muzzle flat ; premaxillary bones rather long, with two large teeth together, near the anterior end, behind the usual external series. Maxillary and mandibles with a single series of simply cylindric curved teeth. Mandibular rami closely articulated by ligament.

The teeth in this genus bear a superficial resemblance to those of a mosasauroid genus. Their mode of succession appears to be as follows :

The crown of the young tooth was developed in a capsule at the base of the crown, or on the inner side of the apex of the thick root. The absorption which followed excavated both the former and the latter, but the crown was evidently first shed. Finally, the old root disappeared, and when the new one occupied the alveolus, it left a free separation all round. Finally, on the accomplishment of the full growth of the root, it became ankylosed to the sides of the alveolus. The pleurodont position of the tooth facilitated the shedding of the root very materially.

The genus *Conosaurus*, Gibbes, from South Carolina, is, perhaps allied to this one. Its dentition is fully described by Leidy, who changes the name to *Conosaurops*, mainly on account of the inappropriateness of the Greek *Σαυρος* to a fish. This word was, however, employed by the ancients to designate a fish, and the only use made of the word out of composition, by modern zoölogists, is for species of that class, so that it does not seem improper to use it here.*

Three, perhaps four, species left their remains in the strata examined by the expedition.

PACHYRHIZODUS CANINUS. Cope. sp. nov.

Established on portions of, perhaps, two individuals, which embrace one nearly complete maxillary bone, two premaxillaries of opposite sides, two nearly perfect rami of the mandible, with numerous other portions in a fragmentary condition.

These indicate a cranium of about a foot in length, by six and a half in width, oval in outline, with moderately obtuse muzzle. The mandibular teeth are directed somewhat outwards ; the premaxillary is horizontal in front, and the maxillary narrow. From these facts I derive that the head was probably depressed, as in the modern *Sauri*, and very different from the prevalent compressed form of the *Porthei* and allies.

* The case appears to me to be different with the name *Ischyrosaurus*, which I proposed to replace with *Ischyrotherium* (Leidy). The latter was given to a genus of saurians, under the supposition that it belonged to the *mammalia*, and the termination, *therium*, devoted to this group of animals by meaning and custom, cannot be applied to a sauriam by any stretch of metonymy or charity.

The *premaxillary* is several times longer than wide; posteriorly it is a subvertical plate; anteriorly it terminates in a narrow obtuse portion. Just behind this portion it is enlarged on the inner side, forming a knob, whose upper surface supports the articulation with the ethmoid. It bears the two large teeth below, on a common elevation of the jaw. The outer margin of the bone supports ten sub-equal teeth, which are one-third smaller than the posterior pair. The outer alveolar ridge is a little more elevated than the inner, though a little less so than on other bones which support teeth. The external face of the bone is nearly smooth, and the inner unites with the maxillary by striate squamosal suture.

The *maxillary* preserved is nearly perfect, and may belong to another animal; its depth coincides with that of the premaxillary. It is quite elongate, about nine times as long as deep, perhaps a little more. It supports forty-two closely packed teeth, not all in functional service at once. The distal end is contracted and grooved and ridged on the inner face, as though for union with a supernumerary bone. The external face is longitudinally striate on the posterior half, the striæ running out to the margins, forming sharp rugosities on the alveolar border. The superior (palatine) articular surface is more than one-fourth the total length from the anterior extremity; it is narrow and somewhat lens-shaped. Both behind and in front of it, strong striæ run from the outer to the inner side of the superior margin, sub-longitudinally. Posterior to the superior articular surface on the outer face is a swelling like a muscular impression, from which grooves and keel extend posteriorly. The bone is concave on the outer face in front, to accommodate the *os premaxillare*.

The *mandibular rami* are abruptly incurved at the symphysis, which is not serrate, is sub-round, with an emargination entering from the inner inferior side. The dentary bone is much narrowed behind. The *angular* bone extends anteriorly on the inner face to the end of the posterior, two-fifths of the dental line. The ramus is not very deep at the coronoid region. The articular cotylus is composed more largely of the angular than the articular. Its long diameter extends inwards and backwards, and is strongly convex; in the transverse direction, slightly concave. Below and in front of it the lower margin of the jaw is acute. The angle is oval and rather small, it is prominent on the middle line on the inner side, the edges are thin, the upper curved outwards, concealing part of the cotylus. There are twenty-nine teeth on the dentary, whose sizes diminish towards its extremities. Their roots are very large and longitudinally striate and porous. Opposite the interval between the first two teeth, there is a tooth exterior to the general row, and another on its inner side. They are not enlarged.

No *teeth* are preserved except on the maxillary. These are not very elongate cones, with round section, and well curved inwards. Dense external layer entirely smooth.

This species differs from the type *P. basalis*, Dixon, in that the radical portion of the tooth is less swollen, and more conic, and does not project above the exterior alveolar wall as in that fish.

Measurements.

	M.
Total length mandibular ramus.....	0.267
" of tooth line.....	.170
Transverse diameter of symphysis.....	.018
" " base of tooth.....	.004
Length premaxillary.....	.068
" " to large tooth.....	.01
Greatest depth ".....	.018
Diameter large tooth at base.....	.007
Length maxillary to first tooth.....	.171
Depth " at " ".....	.019
" " at last ".....	.014
" articular surface.....	.0245

Found by the writer near Fossil Spring, near Fort Wallace, in Western Kansas.

PACHYRHIZODUS KINGII. Cope. sp. nov.

Established on the proximal portion of a maxillary bone with the articular surface, and bases of twelve teeth. It is a species of nearly the same size as the last, but the bone contracts more rapidly than in that one, and presents a stronger interior longitudinal ridge. The superior articular face is smaller and narrower, being sub-crescentic, while the insertion-like tuberosity is nearer to it, and on the inner edge of the outer face, and connected with the articular face by a ridge, not separated by a groove as in *P. caninus*. The outer face is depressed below the articular face much more than in that species, so that its lower portion becomes more convex. The roots of the teeth are of the same length as in *P. caninus*, and as they are more numerous, they are more closely packed and more cylindric. Their pleurodont character is also more strongly marked. The superior surface of the bone is striate grooved longitudinally, and transverse or obliquely.

	M.
Total depth of bone at articular face.....	0.022
Depth at tenth tooth.....	.0155

This species was found near the preceding. It is dedicated to Doctor William Howard King, Post Surgeon at Fort Wallace, to whom, and not less to his excellent wife, I am indebted for hospitality and other assistance of a kind essential to the success of my explorations in Western Kansas.

PACHYRHIZODUS LATIMENTUM. Cope. sp. nov.

Represented by a right ramus mandibuli with the angle and cotylus deficient. The posterior portion of the dentary is also wanting, so that the number of teeth it supported is not ascertainable. The general form appears to have been deeper than in the *P. caninus*, while the size of the teeth is similar. The external face of the bone near the alveolar border is convex, and not particularly rugose. The external alveolar wall is well elevated above the inner. Below the latter, the dentary bone ex-

hibits a strong longitudinal ridge. The extremity of the dentary takes a wider curve from the symphysis than in *P. caninus*, giving a broader chin (whence the name) and muzzle. The symphysis is smooth transverse trilobate, the two outer lobes being separated by an emargination in the position of the foramen mentale. This form is very different from that in *P. caninus* where the symphyseal surface is sub-round.

The anterior teeth are smaller than the median, and have the inner alveolar wall nearly as much elevated as the external. The crowns are scarcely distinguishable from those of the *P. caninus*, being curved conic, with round section and smooth cementum. They form a single incurved row next the symphysis. Number of teeth in an inch at middle of ramus, 4.5.

From a cañon near the Smoky River near to the *Ichthyodectes anaides m.*

PACHYRHIZODUS SHEARERI. Cope. sp. nov.

Associated with the bones of the *P. caninus* is a slender bone of oval section, which is marked on one edge by twenty-two transverse alveoli whose outer margin are a little higher than the inner. No teeth preserved. It may belong to a fish of this genus, and is probably a superior maxillary bone. Constantly with this position its outer extremity is more compressed than the proximal, the thickening being especially seen in the superior margin. A shallow concavity passes obliquely across this border from within outwards and distally as in *P. caninus*, but the articular face is not preserved. There is a longitudinal angle on the external face, and the superficial layer of bone is nowhere grooved or rugose. The pleurodont character of the tooth attachment is more marked proximally. Length of piece, M. .041; vertical diameter, .007; greatest transverse do., .0033.

This species is dedicated to Doctor Shearer, Assistant Post Surgeon, to whose interest in the subject, the Geology of Kansas is indebted for many useful discoveries.

EMPO. Cope.

In this genus the character of the teeth is quite similar to that of the preceding group, but the arrangement on the maxillary bone is different.

The characters are:

Maxillary teeth anteriorly in two series, an external marginal of sub-equal teeth, and an inner and superior of probably small extent, but which terminates anteriorly in two large canine teeth.

Only one species is known to me.

EMPO NEPAHOLICA. Cope. sp. nov.

Established on a portion of the right maxillary bone of a single individual. It displays the anterior squamosal suture for the premaxillary, and not far posterior to this on the superior margin, a concavity for contact with palatine, pre-frontal or other bone as the case may be. The posterior portion is lost. The premaxillary sutural margin extends at right

angles to the alveolar edge to beyond the middle line of the side of the maxillary. Above this point a process of the latter extends above the premaxillary for half an inch; it has a broad inferior sutural face; its upper margin is thin and oblique. A short truncate process rises behind the superior cotyloid surface. The teeth are cylindric conic, slightly incurved; on a margin of .035 M. there are five teeth and five vacant alveoli. The teeth of the inner row are much smaller, and on .017 M., there are eight bases. The bases of the two large teeth occupy .014. Depth of maxillary at large teeth, .019; at fractured end, .014. The anterior teeth of the external series are not larger than those of the inner.

The precise locality of the Niobrara chalk where this species was found has been mislaid. There is a possibility of its belonging to the *Pachyrhizodus latimentum*, but the smaller relative size seems to contradict the supposition. Should it be verified, the latter species must be referred to the genus *Empo*.

STRATODONTIDÆ.

In this group I have arranged several genera which resemble *Enchodus*, the longest known of its forms. They are Physostomous fishes as indicated by the relations of bones of the superior arch of the mouth; the absence of spinous dorsal radii; the cycloid scales, and the general relationship to *Esox*. Agassiz and others have regarded some of them as allied to *Sphyræna*; this opinion was probably derived from the consideration of the forms of the teeth which to some degree resemble those of *Sphyrænidæ* and *Trichiuridæ*. This is, however, like many other minor characters, one of those which appear in both of the great groups of osseous fishes.

The premaxillary is small, and supports a large tooth in *Enchodus*; in *Stratodus* it is also short and supports numerous teeth. In *Stratodus* the maxillary supports a few teeth, in *Cimolichthys* a larger number. Relationship to *Esox* is displayed by *Stratodus*, which has broad flat palatine bones closely studded with teeth in a brush, and where the maxillary teeth are reduced in size and number. The teeth are attached by the ankylosis of the base to the alveolar face of the jaw, resembling thus existing fishes, and differing materially from the families of *Pachyrhizodontidæ* and *Saurodontidæ* already considered.

The genera known to me are the following:

- Premaxillary with numerous small teeth, maxillary with a few of the same; palatines covered with brushes of similar teeth, all with pulp cavity..... *Stratodus*.
- Premaxillary (?) Maxillary with a single series of large teeth which have one cutting edge at base and two at apex. Dentary with inner series of large teeth which do not enlarge distally, and some series of exterior smaller teeth..... *Cimolichthys*.
- Premaxillary with a single large tooth; dentary with an outer row of small and an inner row of large teeth, which are much larger at the distal end..... *Enchodus*.

STRATODUS. Cope.

This genus is well characterized by its dentition, which is remarkable for the small size and large number of the teeth, and their peculiar form. I possess one premaxillary, a considerable part of the maxillary, and nearly the whole of both palatines, besides other bones of one species. These were found not very far from the remains of the *Cimolichthys semianiceps m.* and it required some investigation to determine the relationship between them. I have, however, portions of the maxillary and premaxillary of *Cimolichthys*, and both of these elements are so very unlike those in *Stratodus*, that there can be no doubt of its independence. I have, unfortunately, no dentary bone of *Stratodus*, and the outer row of palatines resembles in some measure those figured in *Cimolichthys levesiensis*, Leidy, by Agassiz.

The *premaxillary teeth* are in two series. They are stout at the base and oval in section, and are contracted and flattened rapidly upwards. On this basis is set an oval sharp edged flat, or spade-shaped crown, the long axis of compression being placed at right angles to that of the compression of the apex of the base. This gives a barbed appearance. The *maxillary teeth* are similar in form, but are in but few rows. The *palatine teeth* are constructed on the same plan, but they are longer, and the bases are subcylindric and slightly curved. All the teeth possess a large pulp cavity.

The *premaxillary bone* displays some of the density of composition seen in *Enchodus*. Its upper anterior surface meets the inferior of an acute angle. It is a broad oval, and is slightly concave. The inner face forms a truncate rim round the bases of the inner teeth, and terminates in a vertical crest of dense bone. The external face is, on the other hand, perpendicular, and extends obliquely upwards and backwards. An acute anterior angle of the *maxillary* under-runs it below, so far as to exclude all but one or two of the premaxillary teeth from the outer row. The external lamina of the premaxillary forms an extensive squamosal suture with this part of the maxillary by overlapping it from above.

This arrangement shows a certain similarity to *Esox*, especially in the large number of palatine and small number of maxillary teeth. It differs materially in the lack of articular surfaces between the maxillary, palatine, etc., in the upward prolongation of the premaxillary, and the peculiar forms of the teeth.

STRATODUS APICALIS. Cope. sp. nov.

Established on one incomplete individual, as above mentioned.

The maxillary teeth are mostly smaller than the premaxillaries, and diminish in size posteriorly; there are four or five series of them anteriorly. Seven to nine rows on the palatine bones; they are slender and curved downwards from oblique bases, and cylindric in section; they contract to a neck and then expand into the ovate spade-shaped cutting apex. They are in every respect the largest of the teeth, some making

a half inch in length. Those on the inferior or outer margin are most slender; those of the inner stouter and more conic. All the spade-like apices are black in the specimen, while the shanks are pale, except the premaxillaries. The *palatine bones* are flattened in one plane, and contracted at both ends. At the anterior, there is an external concavity perhaps for maxillary or premaxillary. A ridge divides the upper surface lengthwise; the outer edge is thin posteriorly, and there are two long grooves which extend to the posterior extremity, probably for sutural union with the pterygoid. The *premaxillary* bears a slight resemblance to the mandibular bone of a Chimæroid turned upside down.

	M.
Length portion of an <i>os palatinum</i>	0.128
Do. restored.....	148
Greatest width.....	.02
“ thickness on margin.....	.003
Length premaxillary, fragment.....	.043
“ “ inner side.....	.025
“ “ outer to maxillary.....	.012
Width “ in front above.....	.01
Length premaxillary tooth.....	.005

This fish was considerably larger than *Esox reticulatus* or *E. lucius*. In the lack of mandible its habits cannot be fully inferred, but the armature of the superior bones of the mouth is less powerful relatively than in those fishes.

Found by myself in the blue limestone shale on Butte Creek, south of Fort Wallace, Kansas.

CIMOLICHTHYS. Leidy.

Proceed. Acad. Nat. Sci. Phila., 1856, p. 202. Trans. Amer. Philosoph. Soc., 1856, p. 95. *Saurodon*, Agassiz, pt. Poiss. Foss.

In this genus the principal teeth are stout, and have a compressed apex with a prominent anterior cutting edge, and a less extended posterior one. There are several series of smaller teeth external to the large ones in the lower jaw, while in a portion of an upper jaw of one of the species these are wanting. Where present, they are more acute than the larger ones. The large teeth diminish gradually in length to the symphysis, a circumstance which separates these fishes from *Enchodus*, where one or more of the anterior teeth are elongate. In the species here described, the bases of the teeth are enlarged and deprived of cementum coat, but there are no true roots.

The maxillary bone terminates in a narrowed extremity with obtuse termination as in *Stratodus*. The vomer in one of the species is acuminate at one end, and supports a short series of teeth, the middle portion in a double row. All the teeth are without pulp-cavity.

The only indication of the mode of succession of the teeth is furnished by the specimen of *C. anceps*. Here a small excavation appears on the

inner side of the basis of the tooth. The absorption commencing at this point no doubt removes the bases so that the crown falls away.

The name used was applied by Dr. Leidy to a fish erroneously referred by Agassiz and Dixon to *Saurodon*, Hays. He did not characterize it, and until the barbed palatine teeth characteristic of it are discovered in our species, their reference to it will not be fully established. In the parts preserved they appear to be identical.

The general affinities of the genus will receive new light from materials now in my possession and not yet developed.

The *Sphryiæna carinata*, Cope (Hayden's Rept. Wyoming, etc., p. 424), probably belongs to *Cimolichthys*.

CIMOLICHTHYS SULCATUS. Cope. sp. nov.

Indicated by a left dentary bone with attached parts of angular, etc. The fragment supports thirteen teeth at equal distances, the intervals often presenting traces of tooth bases. The bases of the teeth are round and the crowns become compressed to the tip. They are strongly curved backwards and acute: The anterior margin is particularly convex and acute, forming a cutting edge, but there is no edge on the posterior face. The surface is rather finely striate-grooved on the inner and posterior faces. The teeth of the exterior series are in several rows, that next the large teeth being considerably larger than the others. They are curved inwards and are flattened, having cutting edges on both anterior and posterior margins. Cementum smooth. The external smaller teeth are shorter in relation to their length, not curved, and two-edged.

The dentary bone contracts irregularly to the symphysis, and has a thickened inferior margin. The symphyseal surface is small, and presents a marked fossa. The external face of the bone is divided by a deep longitudinal groove which is overhung by the produced extremity, and which gives exit to the mental foramen. The external face of the dentary has an impressed groove along its lower third anteriorly, and its surface is sculptured with deep longitudinal sulci, which often run together.

	M.
Length of fragment.....	.018
Depth of first tooth.....	.01
" seventh " .....	.028
" tenth " .....	.045
Total elevation of fifth tooth.....	.014

The restored cranium of this fish is about one foot in length.

From near the Smoky River in Western Kansas.

CIMOLICHTHYS SEMIANCEPS. Cope. sp. nov.

Established on remains of two individuals. One of these embraces vertebrae, portions of vomer, maxillary, mandibular and other bones with some scales. The other consists of a dentary bone with symphysis and teeth.

These indicate smaller individuals than that typical of *C. sulcatus*, but the principal difference is to be seen in the teeth. These are rather more elongate, and they have a cutting edge on the posterior aspect of the apex as well as on the anterior. It extends but a short distance while the anterior rises near the base, and is strongly convex. The tooth curves backwards; the base is round in section. The convex posterior and the inner faces are rather finely striate-grooved. The larger teeth of the external series are convex on the inner face; they are two-edged, and slightly incurved.

The outer face of the *dentary* bones is strongly longitudinally parallel sulcate. The inner face and the surfaces of all the other bones are minutely striate exactly as in some of the *Mosasauroids*, *Clidastes propython*, for example. The anterior extremity of the *maxillary* is straight on one side, and obliquely beveled on the other to an obtuse compressed apex. The bevel becomes sub-horizontal posteriorly, indicating a rather shallow bone. Two of its anterior teeth are a little larger than those that follow. The supposed *vomer* is narrowed to a beak posteriorly (?), and presents an elevated longitudinal and obtuse ridge on the middle line. This supports a row of nine teeth, five of them having mates. The bone expands at the other end for a squamosal articulation with other elements. The vomerine teeth are smaller than the larger dentaries.

The *vertebræ* are elongate and much contracted medially; the rims of the cups are thickened, and the cups themselves very deep. There is a trace of a single median longitudinal groove. The neural and hæmal arches are represented by broad longitudinal laminae in the specimens. The *vertebræ* are thus very different from those of the *Saurodontida*, and bear more resemblance to those of *Cyprinodontida*.

In the *ramus* with symphysis, the characters of the latter resemble those in *C. sulcatus*. It is very small, and does not exhibit the fossa of the latter species. The mental foramen does not continue as a groove to the edge, while there is a deep groove on the inner face opposite to it, not seen in *C. sulcatus*.

The first described specimen would have been, perhaps, a twenty-five pound fish in life. Both specimens were from near Butte Creek, at some distance apart.

CIMOLICHTHYS ANCEPS. Cope. sp. nov.

Established on portions of a right maxillary bone of one individual, and, perhaps, the premaxillary of a second. The former supports six teeth and four empty alveoli.

In accordance with characters derived from study of *C. semianceps*, there is no external series of smaller teeth on the maxillary. The maxillary has a flattened anterior extermination, somewhat as in *Stratodus apicalis*, the superior face being excavated and widened and gradually descending to meet the inferior. The line of junction, where also the premaxillary commences, is oblique from before inwards, and backwards. The anterior tooth is a little larger than those following. The form of

the teeth differs much from that seen in the species just described. They have an oval section at base, but speedily become much compressed in a direction oblique to the long diameter of the bone, and develop cutting edges opposite to each other, and separating equal faces. The crown is a little more convex on one edge than on the other, and has a slight inward curvature. The apex is sharp. The cementum of the crown is smooth, but the surface of the basal portion below the commencement of the cutting edges is minutely striate-grooved, some grooves being deeper than others, the surface having a silky lustre.

The surface of the bone where preserved is without special sculpture. The upper margin is grooved for articulation with a supernumerary maxillary.

	M.
Teeth in M. .01, two.....	
Length of last maxillary tooth.....	0.008
Long diameter of basis of ".....	.004
Depth maxillary bone at ".....	.012

The premaxillary bone belonged probably to a smaller fish. It has the characters seen in *Enchodus* but is shorter and deeper than in the known species. The lateral groove is here subvertical and on the anterior face extending to near the basis of the tooth. The inferior face behind the tooth expands gradually to its base, which is marked by the narrow crescentic scar of the older tooth seen in *E. pressidens*. The crown of the tooth was scarcely as large as that of the maxillaries, but is lost. Its basis is fluted, and the surface finely striate. Length of bone, M. .015. This specimen was not found with the preceding. The latter was discovered on the same bluff that produced the *C. semianiceps* and the *Stratodus apicalis*, at some distance from them.

CIMOLICHTHYS GLADIOLUS. Cope. sp. nov.

Represented by a single elongate tooth which is intermediate in character between those of the two species last described, but much larger than either. It is too large for an anterior maxillary tooth of *C. anceps* and should it pertain to the end of the mandibular series, will in so far resemble the genus *Enchodus*. But the cutting edges are opposite to each other, and not, as is usual in that genus, on one side, leaving the inner face very convex. In this species the crown is rather slender and compressed above the base. The anterior cutting edge extends to the bottom, while the posterior reaches only half-way down; there is no barb. The section of the base exhibits an angle in continuation of the latter. The inner face is a little more convex than the outer; its posterior half is rather coarsely striate keeled. The posterior half of the outer face is finely striate. The inner posterior aspect of the root presents a cavity of absorption for the successional tooth, as in *C. anceps*. The cutting edge and top of apex are glossy black. Length from fossa, M. .019; diameter at do., .006.

From a locality at a short distance from that of *C. anceps*.

ENCHODUS. Cuvier.

Remains of species of this genus occur in the cretaceous strata of Kansas. I discovered a tooth belonging to one of them, in the matrix beneath the vertebræ of *Elasmosaurus platyurus*. Dr. Leidy describes a species* from the cretaceous formations of the Upper Missouri region, which he called *E. shumardii*. The premaxillary of a rather large species was obtained by my expedition, but the species is not determinable. The diameter of the basis of the tooth is M. .012. The long tooth of a species of medium size was detected, as follows :

ENCHODUS CALLIODON. Cope. sp. nov.

Enchodus sp. Cope. Hayden's Surv., Wyoming, etc., p. 424.

The tooth on which this species rests is especially elegant. It is quite slender, and gradually contracts to the acute apex. The cutting edges, which extend to the base, are on one side, and are separated in one direction by a narrow, slightly convex, and perfectly smooth face. The inner face is strongly convex, being more than half a circle from the middle of the length downwards. This is also smooth on its anterior and posterior aspects, but on the inner, there are nine sharp delicate keels which disappear as the tooth contracts, the last terminating with the third quarter of the length. Total length, M. .02 ; longitudinal diameter at base, .0025 ; transverse do., .0035. The apex of the tooth is black.

From near Fossil Spring, Western Kansas.

(?)—————

ANOGMIUS. Cope.

(Proceed. Amer. Philos. Soc., 1871, p. 170.)

This name was applied to a genus supposed to be allied to the *Sauroidontida*, and represented by vertebræ only. One species was named *A. contractus*, Cope, l. c., which was found by Professor Mudge. I have seen nothing resembling these vertebræ among either of the three families above described, and cannot ascertain their exact affinities without further investigation. It is clear that they are not referable to the known genera of *Sauroidontida* nor of *Stratodontida*. They present a marked character in the crowding together of those caudal vertebræ which precede those that support the caudal fin. The centra are shortened and the prolonged neural and hæmal arches and spines lie one on the other, forming a fan-shaped body. The arches do not, at the same time, become ankylosed. This structure is seen in the *A. contractus* and in a second and smaller species. It finds a parallel in the caudal vertebræ of the genus *Ischyrhiza* of Leidy from the green sand of the New Jersey cretaceous, where all the elements of this fan-shaped body, centra, spines, etc., are coössified into a solid mass. This will define family. A species having the same structure is common in the Miocene of Maryland. In

* *Enchodus shumardii*, Leidy, Proc. Ac. Nat. Sci., Phil., 1856, p. 257. is a smaller species than any of the Cimolichthyes here described.

Anogmius, the sides of the centra, though lacking the grooves of other genera, are striate-grooved and reticulate. So are those of *Ischyrrhiza*, and both in this resemble the recent genus *Esox*. Add to this the fact that the teeth of *Ischyrrhiza* are almost exactly like those of *Esox*, especially as to their large fissured fangs, and half pleurodont insertion, some relationship to the *Esocidæ* may be predicated. This is the first hint I know of as to the affinities of *Ischyrrhiza*.

Anogmius contractus was about the size of *Ichthyodectes prognathus*; the second *Anogmius* is not more than one-third the size, the caudal vertebræ are more aggregated, and the neural spines after leaning backwards are turned upwards. The specimen came from Lower Butte Creek; no parts of cranium or fins were found. The vertebræ originally described by me as pertaining to *Ichthyodectes ctenodon* belong either here or to *Ischyrrhiza*; they agree with the latter in most respects, having the neuropophyses coössified with the centrum. They are several times larger than those of *A. contractus* and relatively shorter, being about equal to those of *Ischyrrhiza mira*, Leidy.

I do not name these species, as they may be *Pachyrrhizodontidæ*, and will be in any case better identified from cranial and fin remains.

SELACHII.

Remains of sharks and rays are far less abundant in the cretaceous of Western Kansas than in New Jersey, and are much exceeded in abundance by the *Physostomus Actinopteri*, as the present account indicates. In the region near Fort Hays and Salina, sharks' teeth are more frequently found. Those from near Fort Wallace belong to but two species of the genus.

GALEOCERDO. Müll. Henl.

GALEOCERDO CRASSIDENS. Cope. sp. nov.

Established on two teeth of the type of *G. aduncus*, Agass., *i. e.*, with one cutting edge much more convex than the other. The processes of the fang are rather narrow, that beneath the convex cutting edge the most so. The apex of the tooth is very short, entirely plane, and stands over the middle or inner edge of the wider process of the fang. The shorter cutting edge is straight or convex to near the base, where a short divergent keel develops itself. The anterior edge is strongly convex, and all the edges are denticulate. One side is more convex than the other. No denticles. Cementum smooth.

	M.
Length basis.....	0.014
Height crown.....	.01
" root.....	.005
Width tooth at contraction.....	.01

GALEOCERDO HARTWELLII. Cope. sp. nov.

This species is of the *edgertonii* group, *i. e.*, with the cutting edges sub-equal and symmetrical. The basis is broad and with convexities of

the fang instead of the processes of the last species. The external parts of the cutting edge rise slowly from the base, and then rise more steeply at an obtuse angle. They are convex on each side above, and meet symmetrically, forming a little less than a right angle. No denticles; cementum smooth. Edge everywhere denticulate. One side of crown plane, the other convex.

	M.
Length basis.....	0.0115
“ fang.....	.0495
Elevation of apex (from concavity).....	.0145
Width crown at contraction.....	.042

This tooth is stouter and larger than that of *G. edgertonii*, and was found beneath the bones of the *Protostega gigas*. It is named after Martin V. Hartwell, a member of my expedition, to whose acuteness and industry I owe many specimens.

GENERAL OBSERVATIONS.

The following species have now been described from the cretaceous formation of Kansas :

SAURODONTIDÆ.

- Portheus molossus*. Cope.
Portheus thaumas. Cope.
Ichthyodectes anaides. Cope.
Ichthyodectes etenodon. Cope.
Ichthyodectes hamatus. Cope.
Ichthyodectes prognathus. Cope.
Ichthyodectes multidentatus. Cope.
 (?) *Xiphaectinus audax*. Leidy.
Saurocephalus phlebotomus. Cope.
Saurocephalus arapakocius. Cope.

PACHYRHIZODONTIDÆ.

- Pachyrhizodus caninus*. Cope.
Pachyrhizodus kingii. Cope.
Pachyrhizodus latimentum. Cope.
Pachyrhizodus sheareri. Cope.
Empo nepahollica. Cope.

STRATODONTIDÆ.

- Stratodus apicalis*. Cope.
Cimolichthys sulcatus. Cope.
Cimolichthys semianiceps. Cope.
Cimolichthys anceps. Cope.
Cimolichthys gladiolus. Cope.
Cimolichthys (?) *carinatus*. Cope.
Enchodus calliodon. Cope.

FAM (?)

(*Apsopelix sauriformis*. Cope. Hayden's Report, Wyoming, 1871, p. 423.)

SELACHII.

Galeocerdo crassidens. Cope.

Galeocerdo hartvelli. Cope.

Of the preceding twenty-four species, the greater part are Physostomous *Actinopteri*, and there is no species of a Physoclystous family in the list.* No trace of spines or scales of fishes of the latter character have been yet discovered in strata of this period in the West, though one (*Beryx insculptus*, Cope,) has been discovered by Dr. Lockwood in the green-sand marl of New Jersey.

In the second place, it is of importance to observe that the genera have nearly all been obtained from the chalk of Europe. *Portheus* is represented perhaps by some specimens referred to *Hypsodon*; one species of *Ichthyodectes* is figured by Dixon from Sussex, and one of *Cimolichthys* and *Pachyrhizodus* each. *Enchodus* has long been known from Holland, etc., *Apsopelix*, *Empo* and *Stratodus* being so far the only ones not found in Europe. This is of much interest in every respect, and points to the synchronism as generally understood, between the chalk formations of Kansas and of England.

Stated Meeting, February 16, 1872.

Present, 16 members.

President, Dr. Wood, in the Chair.

A carte de visite photograph and letter, acknowledging receipt of diploma of membership was received from Prof. Charles H. Hitchcock, dated Hanover, N. H., February 3d, 1872.

A photograph was received from Rev. E. R. Beadle, dated 1824 Delancey Place, Phila., Feb. 7th, 1872.

Letters acknowledging the receipt of diplomas of membership were received from the Rev. E. E. Hale, dated Roxbury, Mass., Feb. 5, and from Mr. Edward Quincey, dated Dedham, Mass., Feb., 1872.

* In describing *Elasmosaurus* I state that remains of six species of Physoclystous fishes were found in the matrix surrounding the bones. This statement was founded on the assumption of previous authors, that the forms of fishes above described were related to *Sphyraena*.